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# NETVSL—A COMPUTER PROGRAM FOR CALCULATION OF TREE VOLUMES WITH INTERIOR DEFECT

by

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# NETVSL--A COMPUTER PROGRAM FOR CALCULATION OF TREE VOLUMES WITH INTERIOR DEFECT

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## PROGRAM DESCRIPTION

NETVSL is a comprehensive computer program that calculates the volume, surface area, and length of tree boles from stem measurements. These measurements can be obtained either from felled trees, or taken by a dendrometer from standing trees. Volume units include cubic feet and board feet (Scribner and/or International 1/4" log scale). Total stem contents (including forks) and merchantable contents are calculated for each of the three kinds of volume units. Merchantable contents are defined by arbitrary stump heights, log lengths, and top diameter limits. Stem diameters for the ends of logs are interpolated between adjacent measured stem sections. Top diameters for volumes in board feet are defined by the criterion of Mesavage.[1] Deductions from volume in cubic feet are calculated from descriptive measurements of interior defect obtained by destructive sampling of felled trees. In addition, cull in board feet could be deducted by user-supplied subroutines that are called in the appropriate sequence during execution of the program.

NETVSL has been used to calculate the net volume of trees destructively subsampled in the course of timber management inventories, and to estimate gross volume through dendrometry of a subsample in lieu of using conventional volume tables. Other uses would include calculation of net volume for mill-scale studies, presale cruises, and local volume table construction. Because the computations produce both the board-foot scale and the associated volume-surface-length contents, the latter system of units advocated by Grosenbaugh[2] can be interpreted in the widely used, but misleading, units of board feet (log scale) until conversion coefficients based on mill-scale studies provide a more meaningful interpretation. When presale cruises include destructive sampling to estimate defect deductions, this program can be used to generate the tree or log data cards for subsequent expansion by sample-estimation formulae to produce net volume, surface, and length for the entire sale.

Tree data obtained by dendrometry of standing trees can be recorded in the same form for processing by either NETVSL or by Grosenbaugh's[3] STX program with only a minor difference in the coding for forked trees. This uniformity should simplify the training of dendrometer operators. However, the two programs are intended for quite different purposes. NETVSL is most useful when data from felled trees are being augmented by additional measurements of standing trees, or when a variety of merchantability standards must be applied to the same tree data.

## UNITS OF VOLUME

Nine combinations of volume units and merchantability limits are possible at each run. These include volumes in cubic feet or board feet (Scribner and/or International 1/4" log scale). For each of the three volume units, three sets of merchantability limits can be specified: total tree; fixed top diameter, and arbitrary stump height; or variable top diameter and another arbitrary stump height.

Log lengths for board-foot volume calculations are specified at the user's option. Hence, log scaling diameters, positions of minimum top diameters, and stump heights are located by interpolation among the stem sections for the total tree. Table 1 lists the codes identifying the various combinations of units of measure and merchantability limits. These codes appear in the first column of the sample output in figure 1.

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[1] Mesavage, Clement. Definition of merchantable sawtimber height. J. Forest. 63(1): 30-32. 1965.

[2] Grosenbaugh, L. R. Some suggestions for better sample-tree measurement. Soc. Amer. Forest. Proc. 1963: 36-42.

[3] Grosenbaugh, L. R. STX--FORTRAN 4 program for estimates of tree populations from 3P sample-tree measurements. U.S. Forest Serv. Res. Pap. PSW-13, 49 pp. 1964.

*Coded as in table 1*

NETVSL OUTPUT RUN 1 PROBLEM 19 PLOT 99 PAGE 4

| TOP | RUN | PROB. NO. | PLOT NO. | TREE NO. | SPECIES | AGE | SEC. NO. | LOG LENGTH | HEIGHT | DIAMETER | BARK | GROSS VOL. | CULL VOL. | NET VOL. | SURFACE AREA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 1 | 1.00 | 1.00 | 28.97 | 2.79 | 4.58 | 0.31 | 4.27 | 7.59 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 2 | 3.50 | 4.50 | 25.72 | 2.37 | 14.33 | 0.91 | 13.41 | 25.10 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 3 | 4.60 | 9.10 | 22.46 | 2.20 | 14.63 | 0.86 | 13.77 | 29.07 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 4 | 8.20 | 17.30 | 21.94 | 1.97 | 22.05 | 1.67 | 20.38 | 47.66 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 5 | 8.10 | 25.40 | 20.28 | 1.36 | 19.72 | 2.10 | 17.62 | 44.79 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 6 | 8.20 | 33.60 | 19.98 | 1.86 | 18.12 | 2.12 | 16.01 | 43.21 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 7 | 8.10 | 41.70 | 19.08 | 1.86 | 16.86 | 2.13 | 14.73 | 41.42 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 8 | 8.20 | 49.90 | 17.58 | 1.74 | 15.05 | 2.28 | 12.77 | 39.37 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 9 | 8.10 | 58.00 | 16.86 | 1.50 | 13.11 | 1.89 | 11.22 | 36.52 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 10 | 8.20 | 66.20 | 15.24 | 1.32 | 11.55 | 1.47 | 10.08 | 34.48 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 11 | 8.10 | 74.30 | 13.38 | 1.44 | 9.08 | 1.67 | 7.41 | 30.38 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 12 | 8.20 | 82.50 | 11.88 | 0.96 | 7.16 | 1.68 | 5.48 | 27.15 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 13 | 8.10 | 90.60 | 8.94 | 0.96 | 4.88 | 0.88 | 4.01 | 22.22 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 14 | 8.20 | 98.80 | 6.90 | 0.54 | 2.85 | 0.45 | 2.40 | 17.09 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 15 | 8.10 | 106.90 | 5.28 | 0.36 | 1.67 | 0.18 | 1.49 | 12.99 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 16 | 14.10 | 121.00 | 0.0 | 0.0 | 0.71 | 0.05 | 0.67 | 9.75 |
| 1 | 1 | 19 | 99 | 306 | 202 | 220 | 16 | 121.00 | 121.00 | 23.70 | 0.0 | 176.35 | 20.64 | 155.71 | 468.80 |
| FORM FACTOR= .476 VARIABLE TOP= 0.0 VARIABLE BOTTOM= 0.0 BASAL AREA= 3.064 | | | | | | | | | | | | | | | |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 1 | 0.0 | 1.00 | 28.97 | 2.79 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 2 | 3.50 | 4.50 | 25.72 | 2.37 | 14.33 | 0.91 | 13.41 | 25.10 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 3 | 4.60 | 9.10 | 22.46 | 2.20 | 14.63 | 0.86 | 13.77 | 29.07 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 4 | 8.20 | 17.30 | 21.94 | 1.97 | 22.05 | 1.67 | 20.38 | 47.66 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 5 | 8.10 | 25.40 | 20.28 | 1.36 | 19.72 | 2.10 | 17.62 | 44.79 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 6 | 8.20 | 33.60 | 19.98 | 1.86 | 18.12 | 2.12 | 16.01 | 43.21 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 7 | 8.10 | 41.70 | 19.08 | 1.86 | 16.86 | 2.13 | 14.73 | 41.42 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 8 | 8.20 | 49.90 | 17.58 | 1.74 | 15.05 | 2.28 | 12.77 | 39.37 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 9 | 8.10 | 58.00 | 16.86 | 1.50 | 13.11 | 1.89 | 11.22 | 36.52 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 10 | 8.20 | 66.20 | 15.24 | 1.32 | 11.55 | 1.47 | 10.08 | 34.48 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 11 | 8.10 | 74.30 | 13.38 | 1.44 | 9.08 | 1.67 | 7.41 | 30.38 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 12 | 8.20 | 82.50 | 11.88 | 0.96 | 7.16 | 1.68 | 5.48 | 27.15 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 13 | 8.10 | 90.60 | 8.94 | 0.96 | 4.88 | 0.88 | 4.01 | 22.22 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 14 | 8.20 | 98.80 | 6.90 | 0.54 | 2.85 | 0.45 | 2.40 | 17.09 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 15 | 8.10 | 106.90 | 5.28 | 0.36 | 1.67 | 0.18 | 1.49 | 12.99 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 16 | 3.69 | 110.59 | 3.90 | 0.27 | 0.43 | 0.03 | 0.40 | 4.43 |
| 3 | 1 | 19 | 99 | 306 | 202 | 220 | 15 | 109.59 | 110.59 | 23.70 | 0.0 | 171.48 | 20.32 | 151.17 | 455.89 |
| FORM FACTOR= .476 VARIABLE TOP= 3.90 VARIABLE BOTTOM= 1.00 BASAL AREA= 3.064 | | | | | | | | | | | | | | | |
| 5 | 1 | 19 | 99 | 306 | 202 | 220 | 1 | 0.0 | 1.00 | 28.97 | 2.79 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | 1 | 19 | 99 | 306 | 202 | 220 | 2 | 16.40 | 17.40 | 21.92 | 1.96 | 351.40 | 0.0 | 351.40 | 102.41 |
| 5 | 1 | 19 | 99 | 306 | 202 | 220 | 3 | 16.40 | 33.80 | 19.96 | 1.86 | 288.63 | 0.0 | 288.63 | 88.47 |
| 5 | 1 | 19 | 99 | 306 | 202 | 220 | 4 | 16.40 | 50.20 | 17.55 | 1.73 | 220.16 | 0.0 | 220.16 | 81.13 |
| 5 | 1 | 19 | 99 | 306 | 202 | 220 | 5 | 16.40 | 66.60 | 15.15 | 1.33 | 160.83 | 0.0 | 160.83 | 71.21 |
| 5 | 1 | 19 | 99 | 306 | 202 | 220 | 6 | 16.40 | 83.00 | 11.70 | 0.96 | 91.76 | 0.0 | 91.76 | 57.48 |
| 5 | 1 | 19 | 99 | 306 | 202 | 220 | 7 | 6.00 | 89.00 | 9.54 | 0.96 | 18.58 | 0.0 | 18.58 | 16.76 |
| 5 | 1 | 19 | 99 | 306 | 202 | 220 | 7 | 88.00 | 89.00 | 23.70 | 0.0 | 1131.36 | 0.0 | 1131.36 | 417.46 |
| FORM FACTOR= .476 VARIABLE TOP= 9.54 VARIABLE BOTTOM= 1.00 BASAL AREA= 3.064 | | | | | | | | | | | | | | | |
| 8 | 1 | 19 | 99 | 306 | 202 | 220 | 1 | 0.0 | 1.00 | 28.97 | 2.79 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8 | 1 | 19 | 99 | 306 | 202 | 220 | 2 | 16.40 | 17.40 | 21.92 | 1.96 | 331.86 | 0.0 | 331.86 | 102.41 |
| 8 | 1 | 19 | 99 | 306 | 202 | 220 | 3 | 16.40 | 33.80 | 19.96 | 1.86 | 270.80 | 0.0 | 270.80 | 88.47 |
| 8 | 1 | 19 | 99 | 306 | 202 | 220 | 4 | 16.40 | 50.20 | 17.55 | 1.73 | 204.37 | 0.0 | 204.37 | 81.13 |
| 8 | 1 | 19 | 99 | 306 | 202 | 220 | 5 | 16.40 | 66.60 | 15.15 | 1.33 | 147.01 | 0.0 | 147.01 | 71.21 |
| 8 | 1 | 19 | 99 | 306 | 202 | 220 | 6 | 16.40 | 83.00 | 11.70 | 0.96 | 80.67 | 0.0 | 80.67 | 57.48 |
| 8 | 1 | 19 | 99 | 306 | 202 | 220 | 7 | 6.00 | 89.00 | 9.54 | 0.96 | 17.05 | 0.0 | 17.05 | 16.76 |
| 8 | 1 | 19 | 99 | 306 | 202 | 220 | 7 | 88.00 | 89.00 | 23.70 | 0.0 | 1051.75 | 0.0 | 1051.75 | 417.46 |
| FORM FACTOR= .476 VARIABLE TOP= 9.54 VARIABLE BOTTOM= 1.00 BASAL AREA= 3.064 | | | | | | | | | | | | | | | |

Figure 1.--Copy of printed output for one tree shows log data and tree totals.

Table 1.--*Codes for combinations of units of measure and merchantability limits used to identify output*

| Merchantability limits | Units of measure | | |
|---|---|---|---|
| | | Board feet | |
| | Cubic feet | International 1/4" log scale | Scribner |
| | ----------Codes---------- | | |
| Total tree | 1 | [1]4 | [1]7 |
| Variable top diameter and fixed stump height | 2 | 5 | 8 |
| Fixed top diameter and fixed stump height | 3 | 6 | 9 |

[1]For total-tree volumes in board feet, an initial top diameter of 4" is assumed and then increased until the volume of the top log is maximized. The stump height for combinations 4 and 7 is assumed to be one-half foot.

Mesavage's definition of merchantable sawtimber height is used for all six combinations involving board-foot scaling units. That is, the program interpolates to find the location of the minimum top diameter specified by the user. Then the length of the topmost log is reduced in successive intervals of 2 feet so long as the volume of the piece is increased thereby, or until the length of the top log has been reduced to 6 feet. The top diameter as finally established by this analysis is printed and/or punched with the tree totals. However, for forked trees, only the top diameter of the last fork is displayed.

## FORM OF OUTPUT

All tree identification and the computed volume, surface, length, and defect volume data can be printed, punched into cards, or both, for each measured or interpolated section in the tree. However, the data for separate sections can be suppressed in either type of output, so that tree totals only would be printed as in figure 1 or punched into cards. In addition, totals of all the trees in each plot and in each problem can be printed at the user's option. Figure 1 is an example of the printed output for one tree showing both the dimensions of the separate sections, and the tree totals. Output data for log lengths and heights are in feet; diameters and double bark thicknesses are in inches; and surface area and basal area are in square feet.

Format of the punched output follows the sequence of the printed output with three exceptions. First, the number of forks is punched in column 80. Second, section and log detail cards have a "1" punched in column 79 that is replaced by a "2" on tree-total cards. Third, coding for grade of the piece replaces form factor on the section detail cards for cubic-foot volume units (i.e., those coded 1, 2, or 3 in column 1).

Location and identification of the output fields are indicated below:

| Item | Column | Format |
|---|---|---|
| Units and merchantability limits (see table 1) | 1 | I1 |
| Run number | 2-5 | I4 |
| Problem number | 6-8 | I3 |
| Plot number | 9-11 | I3 |
| Tree number | 12-15 | I4 |
| Species | 16-18 | I3 |
| Age | 19-21 | I3 |
| Section number | 22-23 | I2 |
| Section length | 24-28 | F5.1 |
| Height | 29-33 | F5.1 |
| Diameter | 34-37 | F4.1 |
| Bark thickness | 38-41 | F4.2 |
| Gross volume | 42-48 | F7.2 |
| Cull volume | 49-55 | F7.2 |
| Net volume | 56-62 | F7.2 |
| Surface area | 63-69 | F7.2 |
| Form factor | 70-73 | F4.3 |
| or grade | 71-72 | A2 |
| Top diameter for tree | 74-78 | F5.2 |
| Code for detail or total | 79 | I1 |
| Number of forks in tree | 80 | I1 |

## TREE DATA USED

### For Identification

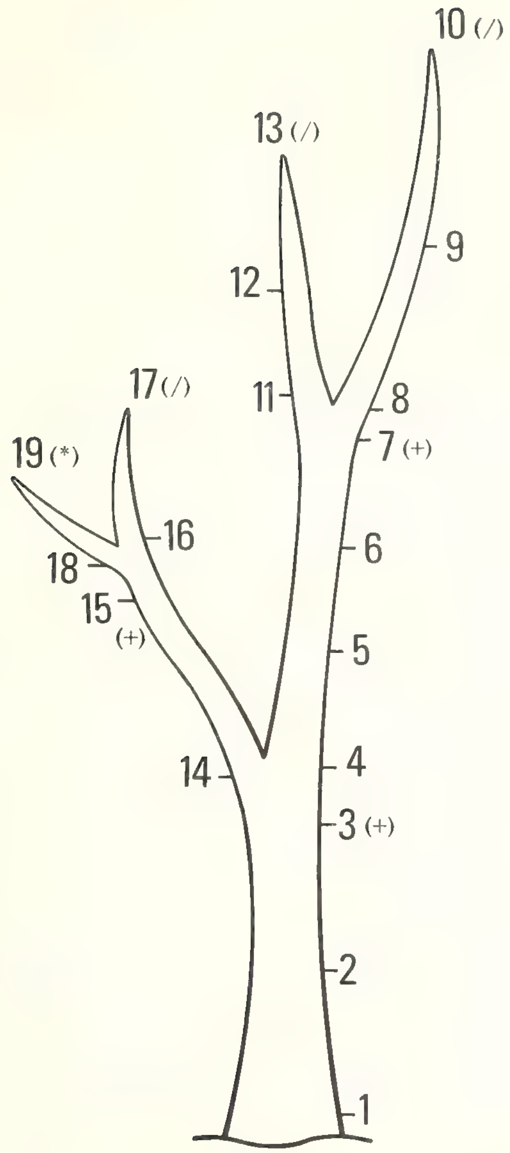
Six items identify the computed data for each tree. On the printed output these are labeled as RUN, PROB. NO., PLOT NO., TREE NO., SPECIES, and AGE. The first pair can be varied if more than one set of calculations is needed from a particular collection of tree data. The last four items are directly associated with the original tree data. Although their names are suggestive, in a specific context their meanings are arbitrary. For example, if the trees had been measured during a 3P cruise (Grosenbaugh[3]) the last four variables might represent sale identification, tree number, stratum, and KPI, respectively, and the output headings would be changed accordingly.

### For Gross Volume, Surface, and Length

Tree data needed for computation of gross volume in cubic feet consist of a sequence of diameters and either lengths of intervening portions[4] or cumulated length from the base of the tree. These measurements may be obtained by tape or caliper measurements of felled trees, or by optical dendrometer measurements of standing trees. At each fork, a section should be measured below the fork on the main stem, and a fork code associated with this section. Another section is recorded immediately above the fork on the main bole, and measurements on up the main bole are continued to the top, with positions of succeeding forks recorded in the same way. When the top of the main bole is reached, the sequence continues up the boles of each preceding fork starting with a section just above the crotch. Multiple forks should be measured and recorded in a sequence such as is diagramed in figure 2.

[3] Grosenbaugh, L. R. STX--FORTRAN 4 program for estimates of tree populations from 3P sample-tree measurements. U.S. Forest Serv. Res. Pap. PSW-13, 49 pp. 1964.

[4] When diameters and intervening lengths are recorded, the diameter at the top of the section is associated with the length of the section.




Note that observations are continued up a bole until an apex is reached. The remaining fork-boles are measured in the sequence of a push-down list--last on is first off. The characters in parentheses represent the characters to be entered in column 72 of dendrometer cards.

**Figure 2.--Sequence of measurements for forked trees.**

If merchantable top specifications include bark and the volume is specified to be inside bark, then the bark thickness should be measured or estimated. If bark thickness is to be estimated by an equation, the calculation can be done in a user-supplied subroutine, BARKEQ, described later in this paper. The intervals between the diameter measurements are arbitrary. However, diameters at abrupt changes of taper should be recorded because scaling diameters for board feet are interpolated for a position corresponding to the top of each log of nominal length plus trim allowance.

## For Defect Volume (Cubic Feet)

Defect is recorded from measurements taken on cut sections. As many as three separate areas of defect can be identified on each section. Because it is necessary to associate the cull areas on succeeding sections, these vertically associated measurements will be referred to as cull columns. Three measurements are used to describe the cross section of each cull column. The first two are dimensions, and the third is a letter describing the shape of the cross section. This latter information is the key to how the dimensions are combined to compute the cross-sectional area of the cull

column. The five shapes[5] for each cull cross-section are coded as follows: (1) rectangular (R), (2) circular (C), (3) elliptical (E), (4) pie-shaped (P), and (5) annular (A).

### For Grade Classification (Cubic Feet)

A grade may be assigned to each portion of the tree between measured diameters. The grade can be any two-character alphanumeric code.

## COMPUTER REQUIREMENTS

The program is written in FORTRAN IV (IBSYS) for operation on the IBM 709X series, and in FORTRAN IV (G or H level) for operation on IBM System 360 computers. It uses three logical input-output units corresponding to the functions of card reader, printer, and card punch. Storage required on the IBM 709X series computers is about 16,000 words, and on the IBM System 360 model 67 about 65,000 bytes are used. These requirements do not include the input-output subroutines.

Source decks of this program may be obtained from the authors.

## PREPARATION OF DATA FOR INPUT

Input to the program consists of a preliminary set of five control cards that identify the run and select options for the final problem, followed by the cards containing the tree data for the first problem. Subsequent problems would each consist of four control cards followed by the corresponding tree data.

Tree data are entered into the computer memory through the subroutine READIN. Two versions of this subprogram are supplied with the program, one for entering data from felled trees, and the other for entering dendrometry data. Specifications for tree data to be read by one or the other of these versions are given below. However, the user may wish to revise the READIN subprogram to suit his specific needs. Information to help a programer revise READIN is provided later in this paper.

## SELECTION OF OPTIONS

A run consists of all data processed at one execution of the program. A run may consist of one or more problems, which are in turn divided into plots. One card selects certain options for the entire run. Three cards for each problem select input-output options and specify units, top limits, stump heights, log lengths, and data format. Finally, a card heading each set of plot data determines the plot summary option.

The format for each of these five option cards and the function each field serves are indicated below:

| Option | Value | Column | Name | Format |
|---|---|---|---|---|
| RUN OPTION CARD | | | | |
| Run number | xxxx | 1-4 | IAPNO | I4 |
| Print a combined summary of all problems? | Yes = 1<br>No = 0 | 6 | IAPSUM | I1 |

[5] The coding provides for 10 shapes, but is now implemented for only these five shapes.

| Option | Value | Column | Name | Format |
|---|---|---|---|---|
| PROBLEM OPTION CARD (1) | | | | |
| Problem number | xxxx | 1-4 | NPROB | I4 |
| Print a summary of all trees in problem? | Yes = 1<br>No = 0 | 6 | IPRSUM | I1 |
| Logical number of input unit[6] for tree data | x | 8 | INPUT | I1 |
| Logical number of output unit[6] for printing | x | 10 | IOUTP | I1 |
| Logical number of output unit[6] for punching | x | 12 | IPNCH | I1 |
| Diameters are recorded in | Inches = 0<br>Feet = 1 | 14 | IFFT | I1 |
| Height defined by summing piece length<br>Height defined as distance from ground to top of section | IFHT = 0<br>IFHT = 1 | 16 | IFHT | I1 |
| Compute bark thickness in subroutine BARKEQ? | Yes = 1<br>No = 0 | 18 | IFBK | I1 |
| Compute defect? If so, what are the units in which it is measured? | No cull = 0<br>Inches = 1<br>Feet = 2 | 20 | IFCL | I1 |
| Will cull codes be used? | Yes = 1<br>No = 0 | 22 | IFCULCD | I1 |
| Will fork codes be used? If so, what character indicates a fork? | No = Blank<br>Yes = Nonblank<br>Character = Nonblank | 24 | IFORKI | A1 |
| Will debugging output be printed? | Yes = 1<br>No = 0 | 26 | IDBUG | I1 |
| Print cubic-foot measurements? | No = 0<br>Tree only = 1<br>Log & tree = 2 | 28 | IOCFW | I1 |
| Punch cubic-foot measurements? | No = 0<br>Tree only = 1<br>Log & tree = 2 | 30 | IOCFP | I1 |
| Print board-foot measurements? | No = 0<br>Tree only = 1<br>Log & tree = 2 | 32 | IOBFW | I1 |
| Punch board-foot measurements? | No = 0<br>Tree only = 1<br>Log & tree = 2 | 34 | IOBFP | I1 |
| Log length (nominal) in feet | xxx.xx | 35-39 | BLEN | F5.2 |
| Trim allowance for logs | xxx.xx | 40-44 | TRIM | F5.2 |

[6] If logical units for input/output are not defined here, the logical unit numbers will be set to the default values contained in the BLOCK DATA subprogram.

PROBLEM OPTION CARD (2)

| | | | | |
|---|---|---|---|---|
| Calculate cubic-foot volume for total stem? | Yes = 1<br>No = 0 | 4 | INTC | I1 |
| Fixed top in inches multiplied by 10 for merchantable volume in cubic feet | xxxx | 5-8 | IVTFC | I4 |
| Stump height (feet) multiplied by 10 to accompany fixed top for cubic feet | xxxx | 9-12 | IVBFC | I4 |

NOTE: If either IVTFC or IVBFC is greater than zero, cubic-foot volume to a fixed top will be calculated.

| | | | | |
|---|---|---|---|---|
| Percent of d.b.h. (o.b.) to be used for variable top for cubic feet in subroutine VARTCF. | xxxx | 13-16 | IVTPC | I4 |
| Stump height in feet multiplied by 10 to accompany variable top for cubic feet. | xxx | 17-20 | IVBPC | I4 |

NOTE: If either IVTPC or IVBPC is greater than zero, cubic-foot volume to a variable top will be calculated.

| | | | | |
|---|---|---|---|---|
| Calculate board-foot volume for entire stem to 4" top? | Yes = 1<br>No = 0 | 24 | INTB | I1 |
| Fixed top in inches multiplied by 10 for board feet | xxxx | 25-28 | IVTFB | I4 |
| Stump height in feet multiplied by 10 to accompany fixed top for board feet | xxxx | 29-32 | IVBFB | I4 |

NOTE: If either IVTFB or IVBFB is greater than zero, board-foot volume to a fixed top will be calculated.

| | | | | |
|---|---|---|---|---|
| Percent of d.b.h. (o.b.) to be used for variable top for board feet in subroutine VARTBF. | xxxx | 33-36 | IVTPB | I4 |
| Stump height in feet multiplied by 10 to accompany variable top for board feet. | xxxx | 37-40 | IVBPB | I4 |

NOTE: If either IVTPB or IVBPB is greater than zero, board-foot volume to a fixed top will be calculated.

| | | | | |
|---|---|---|---|---|
| Log rule for board feet | INT 1/4=0<br>Scribner = 1<br>Both = 2 | 44 | INORSC | I1 |
| Variable top for cubic-foot volume is measured outside bark? | Yes = 1<br>No = 0 | 48 | IDOPPC | I1 |
| Fixed top for cubic-foot volume is measured outside bark? | Yes = 1<br>No = 0 | 52 | IDOPFC | I1 |

| Option | Value | Column | Name | Format |
|---|---|---|---|---|
| PROBLEM OPTION CARD (2) (con.) | | | | |
| Variable top for board-foot volume is measured outside bark? | Yes = 1<br>No = 0 | 56 | IDOPPB | I1 |
| Fixed top for board-foot volume is measured outside bark? | Yes = 1<br>No = 0 | 60 | IDOPFB | I1 |

FELLED-TREE FORMAT CARD (for felled trees, to be replaced by DENDROMETER CONSTANT CARD for dendrometry data)

| | | | | |
|---|---|---|---|---|
| FORTRAN input format enclosed in parentheses | | 1-80 | FMT (for IBM System 360) | 20A4 |
| | | or | | |
| | | 1-72 | FMT (for IBM 709x) | 12A6 |

| | | | | |
|---|---|---|---|---|
| PLOT OPTION CARD | | | | |
| Plot number (must be nonblank and nonzero) | xxxx | 1-3 | NPLOT | I3 |
| Print a summary of all trees in the plot? | Yes = 1<br>No = 0 | 6 | IPLSUM | I1 |

The options selected for each problem are described on the first page of the computer-printed results for each problem (fig. 3). For cross-referencing, the names and values of the variables cuing each line have been superimposed on the output.

```
          NPROB  IOUTP                                INPUT             IPNCH
IN PROBLEM NO,  1 TAPE 6 IS USED FOR OUTPUT AND TAPE 5 FOR INPUT. TAPE 7 WILL BE THE PUNCH TAPE

A SUMMARY WILL BE COMPILED FOR PROBLEM     1   IPRSUM = 1

CUBIC FOOT VOLUME OF THE WHOLE TREE WILL BE CALCULATED    INTC = 1
                                                                                   IDOPPC = 1
CUBIC FOOT VOLUME WILL BE CALCULATED ACCORDING TO SUBROUTINE VARTCF. TOP DIAMETER WILL BE (DOB).
A  3.0 FOOT STUMP HEIGHT WILL BE USED.
    IVBPC = 30           IVTFC = 65        IDOPFC = 0      IVBFC = 15
CUBIC FOOT VOLUME TO A   6.5 INCH TOP (DIB) AND A  1.5 FOOT STUMP WILL BE CALCULATED

BOARD FOOT VOLUME OF THE WHOLE TREE WILL BE CALCULATED   INTB = 1
                                                                                   IDOPPB = 0
BOARD FOOT VOLUME WILL BE CALCULATED ACCORDING TO SUBROUTINE VARTBF. TOP DIAMETER WILL BE (DIB).
A  1.0 FOOT STUMP HEIGHT WILL BE USED.
    IVBPB = 10
BOARD FOOT VOLUME TO A   7.5 INCH TOP (DOB) AND A  2.0 FOOT STUMP WILL BE CALCULATED
                     IVTFB = 75     IDOPFB = 1     IVBFB = 20
BOTH INTERNATIONAL QUARTER INCH AND SCRIBNER BOARD FOOT VOLUME WILL BE CALCULATED  INORSC = 

CULL VOLUME WILL BE CALCULATED. CULL INPUT MEASUREMENTS ARE IN FEET.   IFCL = 

DIAMETER MEASUREMENTS WILL BE IN FEET.   IFFT = 1

THE HEIGHT OF A SECTION IS MEASURED FROM THE  GROUND  IFHT = 1

THE FORK CODE FOR THIS PROBLEM IS   F   IFORKI = F

CULL CODES WILL BE USED TO DETERMINE CULL SHAPE  IFCULCD = 1

CUBIC FOOT RESULTS FOR LOG AND TREE CALCULATIONS WILL BE PRINTED  IOCFW = 2

CUBIC FOOT RESULTS FOR LOG AND TREE CALCULATIONS WILL BE PUNCHED  IOCFP = 2

BOARD FOOT RESULTS FOR LOG AND TREE CALCULATIONS WILL BE PRINTED  IOBFW = 2

BOARD FOOT RESULTS FOR LOG AND TREE CALCULATIONS WILL BE PUNCHED  IOBFP = 2

A PLOT SUMMARY WILL BE COMPILED FOR PLOT  14  IPLSUM = 1
```

Figure 3.--Copy of first page of printed output listing the options selected for problem 1. Values of variables cuing each line have been superimposed on the listing.

## DATA FROM FELLED TREES

Data for each cut section are obtained from cards sorted into sequence beginning at the base of the tree and proceeding up the stem. The format of these cards is specified on the PROBLEM FORMAT CARD. However, the data sequence required by the felled-tree version of the subroutine READIN included with the program is as follows:

| | |
|---|---|
| Plot number<br>Tree number<br>Species<br>D.b.h.<br>Age | Same for all sections in one tree. |
| Height | Height above ground or length of piece. |
| D.o.b.<br>D.o.b. | Outside bark diameters of upper end of the section. |
| D.i.b.<br>D.i.b. | Inside bark diameters of upper end of the section. |
| DBT | Double bark thickness.[7] |
| W1<br>B1<br>J1 | 1st cull dimension of 1st cull column.<br>2nd cull dimension of 1st cull column.<br>Shape code of 1st cull column. |
| W2<br>B2<br>J2 | As above for 2nd cull column. |
| W3<br>B3<br>J3 | As above for 3rd cull column. |
| BW<br>BB<br>JB | Data to be transmitted to user-supplied subroutine to calculate board-foot deductions for defect. |
| IFORK | A fork indicator here means that a fork leaves the bole at this level. |
| IG | Grade of piece below the measurement level. |

The units of measure and other alternatives for the above data depend on the options selected by the appropriate punches on the first problem option card, which was described under the heading "Selection of Options." In the above list, plot number, tree number, species, and age are treated as integer data in the computer program. J1, J2, J3, JB, and IG are treated as alphanumeric data. The remaining variables are stored as floating-point data.

## DENDROMETRY DATA FROM STANDING TREES

Gross volumes of trees measured with an optical dendrometer can be computed with the same options by replacing the felled-tree version of the READIN subroutine with the corresponding dendrometry version of READIN. This latter program accepts tree data measured and punched to the specifications used in Grosenbaugh's STX program with the

[7] DBT does not need to be recorded if it is adequately described by D.o.b. minus D.i.b.

exception of the slash (/) for tops of forked trees. However, the tree extrapolation options provided in STX are not used in NETVSL. Instead, the total height of the stem should be measured so that interpolation of the unseen bole can be accomplished.

Dendrometer constants B, Q, U, and G are entered on a DENDROMETER CONSTANT CARD that replaces the PROBLEM FORMAT CARD in the felled-tree data sequence. For definition of these constants and for their format, refer to the second STX control card, which can be used unchanged for NETVSL.

Tree data are entered on two types of cards: a tree input card and subsequent dendrometer input cards. Corresponding variable names in the two programs for the variables on these cards are as follows:

| NETVSL | Column | STX |
|---|---|---|
| TREE INPUT CARD | | |
| ID | 1-4 | KREENO |
| XJ | 5 | J |
| IAGE | 6-9 | KPI |
| ITYPE | 10 | LST |
| Not used | 11 | XCERT |
| Not used | 12-16 | BETATH (CLASS) |
| DBH | 17-21 | DBH |
| Not used | 22-26 | Tree options |
| XBKA | 27-30 | BKA |
| XBKB | 31-34 | BKB |
| Not used | 35-76 | Extrapolation data |
| XJOB (Plot no.) | 77-80 | Identification |
| DENDROMETER INPUT CARD | | |
| ID | 1-4 | KREENO |
| XJ | 5 | J |
| TGRADS | 12-15 | TGRADS |
| FGRADS | 16-19 | FGRADS |
| SINELV | 20-24 | SINELV |
| IG | 25-26 | GAMATH |
| TGRADS | 27-30 | TGRADS |
| FGRADS | 31-34 | FGRADS |
| SINELV | 35-39 | SINELV |
| IG | 40-41 | GAMATH |
| TGRADS | 42-45 | TGRADS |
| FGRADS | 46-49 | FGRADS |
| SINELV | 50-54 | SINELV |
| IG | 55-56 | GAMATH |
| TGRADS | 57-60 | TGRADS |
| FGRADS | 61-64 | FGRADS |
| SINELV | 65-69 | SINELV |
| IG | 70-71 | GAMATH |
| XTERM | 72 | TERM |
| XJOB | 77-80 | Identification |

The variable XTERM is used by NETVSL somewhat differently than its counterpart in STX. A blank value for XTERM indicates that the current dendrometer card is filled, and more measurements are to be found on the subsequent card. An asterisk indicates the last dendrometer card for a specific tree. A plus sign in XTERM indicates that the last trio of dendrometer measurements was taken at the point where a fork was

encountered. Subsequent dendrometer measurements will continue for this tree on the next card. The tip for each fork *except the last* is indicated by a slash (/) in XTERM of the last card containing data for that fork.

Dendrometry of the two lowest measurement levels may not be feasible. Accordingly, NETVSL follows the STX procedure[8] for substituting tape-measured diameters and lengths. Initial TGRADS should be recorded as a fictitious -999. Then initial FGRADS should be the stump diameter outside bark, in inches and tenths. The corresponding SINELV should be the length between stump top and the next measurement level, recorded in feet and tenths with the decimal point punched. Second TGRADS should be blank, while second FGRADS should be the diameter at the next measurement level (usually b.h.). Second SINELV is recorded as length (in feet and tenths with decimal point punched) between this measurement level and the first actually dendrometered measurement level above. Examples to illustrate these procedures are provided in appendix A.

### TERMINATING PROCEDURE

Transition from cards containing data for one tree to cards for the next tree is indicated by the change in tree number (felled-tree data) or by the terminal asterisk (dendrometry data). The end of a plot is indicated by a blank card. That is, a blank card will suffice so long as the preceding tree number is nonzero.

A second blank card indicates the end of a problem, and a third blank card terminates the run.

## CALCULATION PROCEDURES

### GEOMETRIC ASSUMPTIONS

#### Tree Bole

Wood volume and surface area below the first diameter measurement are computed as though the stump were a cylinder of the given length and diameter. The diameter of the uppermost section of each fork must be zero. If the field measurements do not include the tip of the tree, a fictitious section of trivial length and zero diameter will suffice to permit computation to proceed. No attempt will be made to extrapolate beyond the actual measurements. The volume, area, and any interpolated diameters in the section terminating at the tip are computed as though the section were a right cone. Intervening sections of normal taper are treated as right parabolic frustra. Hence, their volume in cubic feet is computed by Smalian's formula, and the surface area as the surface of revolution of the appropriate parabolic segment. If the diameter at the top of a section exceeds the next lower diameter, the intervening section is treated as an inverted right conic frustrum.

#### Cull Columns

For each cross section, the area of each cull column is computed by the equations shown in table 2 associated with their respective shapes, the dimensions W and B of the cull column cross section, and the bole diameter, D. The volume in cubic feet of a cull column between two succeeding sections is computed by assuming the following geometric shapes having the indicated end areas.

---

[8] This description is paraphrased from the comments in SBR subroutine written by L. R. Grosenbaugh.

Table 2.--*Formulae relating cull cross-sectional area*[1] *to shape, section diameter (D), and cull dimensions (W, B)*

| Shape | Code | Formula for area |
|---|---|---|
| Rectangular | R | $S = W \cdot B$ |
| Circular | C | $S = \pi W^2/4$ |
| Elliptical | E | $S = \pi W \cdot B/4$ |
| Pie-shaped | P | $S = (\pi/4)(D^2/144)\ W/B$ |
| Annular | A | $S = (\pi/4)(W^2 - B^2)$ |

[1]S is measured in square feet. W and B will be converted to feet if cull is specified to have been measured in inches.

(1) A frustrum of a right paraboloid when the defect is visible on both ends of the log.

(2) A right paraboloid tangent at its vertex to the lower end of the portion when the cull is visible only on the cut surface of the upper end.

(3) A right cone with vertex at the upper cut if the cull is visible only on the lower cut surface of the piece.

Inaccurate calculation of volume and surface will result if the tree does not conform to the above abstractions. However, the magnitude of the error can be reduced by closer spacing of the section measurements. If the above assortment of cull shapes does not adequately approximate the cull area, the shape should be designated as R, the first dimension set equal to the true cull area, and the second dimension set equal to 1.

## SUBPROGRAMS INTENDED TO BE MODIFIED OR SUPPLIED BY THE USER

The NETVSL program calls several subprograms to perform certain calculations that users may have reason to modify for local conditions or to meet specific objectives. These subprograms are:

(1) READIN, that transfers data from the card (or tape) source into the appropriate storage location for the variables needed for computation.

(2) BARKEQ, that calculates bark thickness.

(3) VARTCF, that calculates the variable top diameter for cubic-foot volume (output code 2).

(4) VARTBF, that does the same for board-foot volume (output codes 5 and 8).

(5) BRDCUL, that calculates the defect deductions for net board-foot volume.

(6) BLOCK DATA, that establishes values of many variables governing input-output unit assignments, and other constants used throughout the program. Details concerning these subprograms follow.

## READIN

Two versions of READIN have been programed: one for felled-tree data and one for dendrometry data. READIN is called in three ways. The value of the variable ISET indicates the way in which READIN has been called. READIN is called once per problem with ISET=1 to perform initialization such as reading in variable formats, once per plot with ISET=-1 to read data needed to initialize the program for plot data, and with ISET=0 to read data for subsequent trees in the plot.

The task of the READIN is to enter data into the matrices Z and IZ. These matrices will have as many rows as there are measured sections in the tree. The columns are defined as follows:

```
Z (I,1)  = diameter
Z (I,2)  = height above ground or piece length
Z (I,3)  = W for 1st cull column
Z (I,4)  = B  "   "   "     "
Z (I,5)  = W for 2nd cull column
Z (I,6)  = B  "   "   "     "
Z (I,7)  = W for 3rd cull column
Z (I,8)  = B  "   "   "     "
Z (I,9)  = Double bark thickness (only if measured on tree)
Z (I,10) = Optional use for board-foot defects
Z (I,11) =    "      "   "    "     "    "
Z (I,12) =    "      "   "    "     "    "
IZ(I,1)  = Shape indicator for 1st cull column
IZ(I,2)  =   "       "      " 2nd  "    "
IZ(I,3)  =   "       "      " 3rd  "    "
IZ(I,4)  = Fork indicator
IZ(I,5)  = Optional use for board-foot defects
IG (I)   = Grade of the piece
```

In addition, values should be assigned to the following tree variables:

```
ID       = tree number
DBH      = tree diameter, outside bark
IAGE     = data to be listed as "age." Use is arbitrary.
ITYPE    = data to be listed as "species." Use is arbitrary.
```

In the above list, Z is a matrix of real variables; IZ and IG are alphanumeric variables; ID, IAGE, and ITYPE are integer variables; and DBH is a real variable.

When the dendrometer version of READIN is used, set IFFT=0, IFHT=1, and IFORKI=+ on PROBLEM OPTION CARD (1).

## BARKEQ

This subprogram is called from the DIALEN subprogram. It deducts estimated bark thickness from the diameters in the sequence in which they have been stored by DIALEN. The call to this subprogram is bypassed if IFBK (column 18 on PROBLEM OPTION CARD (1)) is zero. The version of BARKEQ distributed with NETVSL estimates double bark thickness

from the ratio of inside-bark to outside-bark diameters at breast height by the relation:[9]

DBT=D(I)*[BARKBH/DBH]*[QUAN/(DENO-D(I)/DBH)]

in which

DBT = double bark thickness
D(I) = outside bark diameter at the level for which bark is being estimated.
DBH = diameter outside bark at breast height (B.H.)
BARKBH = double bark thickness at B.H.
QUAN,DENO = constants establishing the asymptote of the hyperbola, such that DENO-1.=QUAN.

Additional variables available to BARKEQ that are useful for estimating bark thickness are:

ITYPE--the species code
IAGE--the tree age
HT(ITDIA)--the height of the top of the tree
HT(I)--the height at the estimation point

## VARTCF

This subprogram calculates the top diameter to be used with output code 2. The version of VARTCF distributed with NETVSL calculates the variable top as a fraction of DBH. The fraction is obtained from IVTPC/100. The latter variable is input data from columns 13-16 of PROBLEM OPTION CARD (2). The argument list with which VARTCF is called is (DBH, IVTPC/100, IVTFC/IVTFLT, VT).

IVTPC and IVTFC are read from PROBLEM OPTION CARD (2). IVTFLT is a scale factor set to 10 in BLOCK DATA. VT is the calculated variable top. Although IVTFC is available, it should be used with caution because a nonzero value of IVTFC will cause calculation of volumes in cubic feet to this fixed top diameter (output code 3 in table 2).

## VARTBF

This subprogram is analogous to VARTCF except that it uses IVTPB and IVTFB in the second and third calling arguments. A similar caution applies to using the third argument.

## BRDCUL

Defect deductions in board-foot units have not been programed because the rules for these deductions are quite variable. However, the NETVSL program does provide for reading the necessary data and transmitting these data to the BRDCUL subprogram, which is called after log intervals, diameters, and gross volumes have been calculated.

The data for computing cull in board feet are stored in locations identified by the following names:

| | |
|---|---|
| IBOTM(J) | Index of the data for the bottom section of the *J*th fork |
| ITOP(J) | Index of the data for the top section of the *J*th fork |

[9] Clement Mesavage (personal communication) has found that this formulation of the vertical trend of bark thickness has wide generality with QUAN=1, DENO=2.

| | |
|---|---|
| KFORK | Number of forks (equals unity for single-boled trees) |
| HT(I) | Height above ground |
| DIA(I) | Diameter in inches |
| Z(I,10), Z(I,11), Z(I,12) | Board-foot cull dimensions at the *I*th section |
| IZ(I,5) | Shape code for board-foot cull calculations |

(For the above variables, I ranges from IBOTM(J) to ITOP(J).)

| | |
|---|---|
| NOS | Number of logs (plus one for the base of each fork) in the tree |
| BHT(K) | Height above ground of log top |
| BDIA(K) | Diameter at top of the log |
| BFLN(K) | Length of log |
| BBARK(K) | Bark thickness |
| BFVS(K) | Board-foot volume (Scribner) |
| BFVI(K) | " " " (International) |
| BCLVS(K) | " " " in cull (Scribner) |
| BCLVI(K) | " " " " " (International) |

(For the above variables, K ranges from 1 to NOS.)

## BLOCK DATA

Input-output variables are preset in BLOCK DATA to correspond to the system configuration at particular computer centers. The logical units used for I/O are defined by the following self-explanatory variable names: NREAD, NWRITE, and NPUNCH. The number of lines per printed page is set to 60 as the value for the variable LINEC.

Cull codes of C, R, E, P, and A are established in the vector ICLC. The length of ICLC is given by the value of NCODE. The sequence of cull codes should correspond to the sequence implied in the computed GO TO statement in subprogram CUAREA.

## APPENDIX A

### TYPICAL INSTRUCTIONS FOR MEASURING AND RECORDING TREE DATA

Samples of field procedures that have been used to obtain data for processing by NETVSL may be helpful to some users of this program. These procedures have been developed for use under certain of the programed options, and according to decisions on standards of accuracy that were appropriate for the immediate purpose of a particular analysis. Hence, many of these procedures are more restrictive than the program requires. For instance, the opportunity for grade classification is not used explicitly in either example shown below. When questions arise in interpreting these sample instructions, the answers should be sought in the main body of this paper.

The following examples also contain useful test data for new users of NETVSL.

FELLED-TREE DATA SHEET FOR GROSS AND CULL VOLUME

Location no. 113 Tree no. 801 National Forest 014 Date July 8, 1965 Species 073 DBH 223

| | Height above ground | Cubic volume data | | | | | 1st cull area | | | 2nd cull area | | | 3rd cull area | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DOB | | DIB | | DBT | W | B | S | W | B | S | W | B | S |
| | | 1 | 2 | 1 | 2 | | | | | | | | | | |
| | 1.0 | 363 | 363 | | | 045 | | | | | | | | | |
| | 4.5 | 180 | 180 | 158 | 129 | 030 | 180 | 010 | R | | | | | | |
| | 9.1 | 166 | 166 | 148 | 125 | 014 | 200 | 015 | R | | | | | | |
| * | 17.3 | 148 | 148 | 138 | 116 | 008 | 160 | 030 | R | | | | | | |
| | 25.4 | 139 | 136 | 129 | 128 | | 100 | 010 | R | | | | | | |
| * | 33.6 | 134 | 133 | 123 | 129 | | 030 | 005 | R | | | | | | |
| | 37.6 | 131 | 130 | 121 | 125 | | | | | | | | | | |
| | 41.7 | 128 | 127 | 122 | 118 | | | | | | | | | | |
| * | 49.9 | 126 | 126 | 116 | 117 | | | | | | | | | | |
| | 58.0 | 123 | 123 | 113 | 113 | | | | | | | | | | |
| * | 66.2 | 110 | 113 | 103 | 106 | | | | | | | | | | |
| | 74.3 | 103 | 106 | 098 | 099 | | | | | | | | | | |
| * | 82.5 | 095 | 096 | 086 | 085 | | | | | | | | | | |
| | 90.6 | 080 | 081 | 072 | 076 | | | | | | | | | | |
| * | 98.8 | 066 | 066 | 058 | 059 | | | | | | | | | | |
| | 106.9 | 048 | 051 | 043 | 045 | | | | | | | | | | |
| ~~*~~ | ~~115.1~~ | | | | | | | | | | | | | | |
| | ~~123.2~~ | | | | | | | | | | | | | | |
| * | 128.0 131.4 | 000 | 000 | 000 | 000 | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

*Here you felt that DOB-DIB would not give an accurate estimate of DBT so you measured and recorded DBT.*

*No cull observed beyond this point.*

*Indicates that you cut that 8 foot section in two at 4 feet and found that the rot column had run out, so you left the columns under 1st cull area blank.*

*Top of the tree*

**Figure 4.--Sample field sheet for recording felled-tree data.**

## Instructions for Measuring and Recording Data--Felled Trees (Example 1)

A sample field record sheet with data entered is shown in figure 4. The first five columns record the heights above ground at which measurements were taken. Heights that mark the scaling end of 16-foot logs are preceded by asterisks.[10] All data recorded on the same line as any given height are measurements taken at that height.

Proceeding from left to right across the page, under the heading DOB of Cubic Volume Data, record the long and short diameters of the tree trunk outside bark. Columns headed 1 and 2 are provided for these entries. Under DIB are recorded the long and short diameters inside bark. In trees where double bark thickness cannot be accurately obtained by subtracting average DIB from average DOB, enter double bark thickness under DBT. When this is not necessary, leave DBT blank.

Space is provided for recording measurements from three cull areas in the cross section of the tree (fig. 5). For the First Cull Area, enter under W the width of

FELLED-TREE DATA SHEET FOR GROSS AND CULL VOLUME

Location no. 099 Tree no. 306 National Forest 014 Date July 7, 1965 Species 202 DBH 237

| Height above ground | Cubic volume data | | | | | 1st cull area | | | 2nd cull area | | | 3rd cull area | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DOB | | DIB | | DBT | W | B | S | W | B | S | W | B | S |
| | 1 | 2 | 1 | 2 | | | | | | | | | | |
| 1 . 0 | 240 | 292 | 220 | 265 | | 070 | 056 | E | From 1st rot column | | | | | |
| 4 . 5 | 200 | 274 | 243 | 189 | | 061 | 035 | R | | | | | | |
| 9 . 1 | 240 | 176 | 215 | 163 | | 052 | 031 | R | | | | | | |
| * 1 7 . 3 | 210 | 189 | 191 | 175 | | 047 | 027 | R | 040 | 038 | E | | | |
| 2 5 . 4 | 188 | 173 | 172 | 166 | | 031 | 013 | R | 060 | 041 | E | 032 | 015 | E |
| * 3 3 . 6 | 183 | 181 | 169 | 164 | | | | | 053 | 036 | R | 039 | 022 | E |
| 4 1 . 7 | 175 | 174 | 159 | 159 | | From 2nd rot column | | | 042 | 027 | R | 043 | 036 | R |
| * 4 9 . 9 | 162 | 160 | 146 | 147 | | | | | 018 | 022 | E | 060 | 043 | R |
| 5 8 . 0 | 153 | 153 | 140 | 141 | | | | | | | | 057 | 042 | E |
| * 6 6 . 2 | 136 | 140 | 124 | 130 | | | | | | | | 054 | 040 | E |
| 7 4 . 3 | 125 | 122 | 111 | 112 | | 036 | 028 | E | | | | 052 | 040 | E |
| * 8 2 . 5 | 104 | 110 | 098 | 100 | | 039 | 030 | E | | | | 034 | 028 | E |
| 9 0 . 6 | 083 | 082 | 075 | 074 | | 030 | 025 | R | | | | | | |
| * 9 8 . 8 | 063 | 061 | 059 | 056 | | 025 | 014 | R | | | | From 3rd rot column | | |
| 1 0 6 . 9 | 047 | 047 | 044 | 044 | | 014 | 009 | E | | | | | | |
| * ~~1 1 5 . 1~~ 1 2 1 . 0 ~~1 2 3 . 2~~ | 000 | 000 | 000 | 000 | | | | | 4th rot column | | | | | |
| * ~~1 3 1 . 4~~ | Showing how to record top of the tree | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

Figure 5.--Sample field recording sheet for a tree having four columns of interior defect.

[10] Implicit in these heights are the options on stump height, log length, and trim allowance.

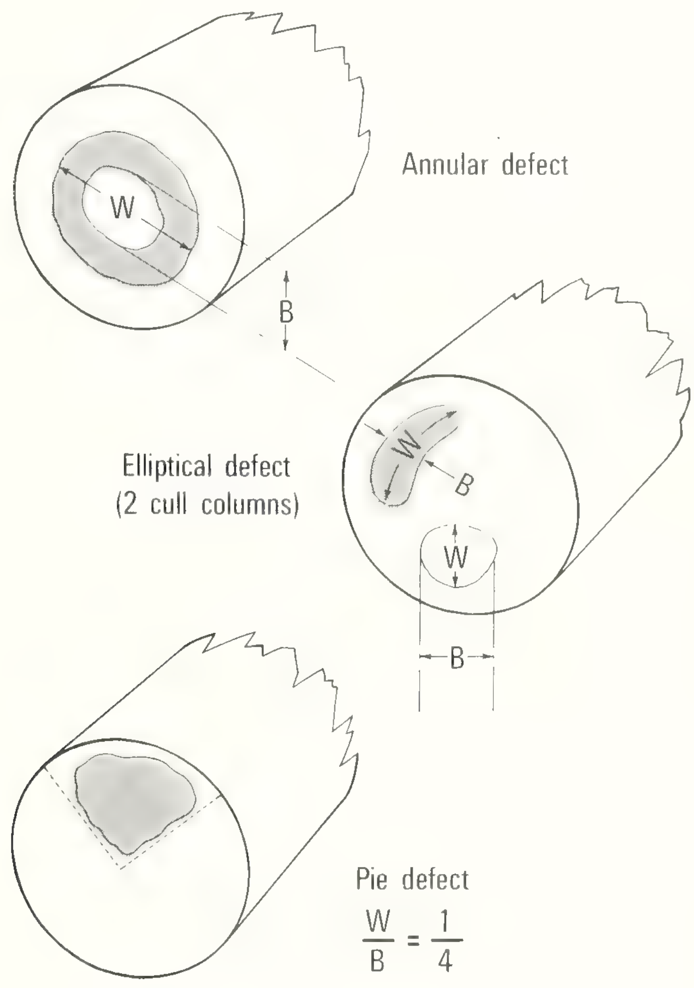
the cull area. Under B enter the breadth of the cull area. As used in this context, width and breadth mean the long and short measurements of the cull area. Under S indicate the shape of figure most closely approximating the cull area. For an ellipse (including a circle) enter E. For a rectangle (including a square) enter R. For ring-shaped defect, the outer and inner dimensions of the ring are recorded under W and B respectively, and "A" is the shape code (fig. 6).

Pie-shaped defect affecting an entire segment of the cross section can be recorded by "P" for shape. Then, W/B is the fraction of the circle to be deducted.

If called for, the procedure outlined for the First Cull Area will be repeated for the Second Cull Area and/or the Third Cull Area.

More than one rot column can be recorded under First Cull Area if there is at least one intervening measured section with no entry in that column.

Figure 6.--Cull shapes and corresponding measurements to describe them.



The same instruction applies to a second or third rot column, if encountered. For example, suppose that a single rot column extends from the stump upward into the tree bole. Designate cross sectional areas of this rot column as the First Cull Area. When a second rot column is encountered, as shown in figure 5, its measurements will be recorded under Second Cull Area. The same would be done for a third rot column. When the first rot column runs out, do not shift columns on the data sheet. Data for a continuous rot column in the tree must be recorded entirely under one cull area column. Continue to record measurements of the second rot column under Second Cull Area until it runs out. Do likewise for the third rot column. If more than three rot columns are found in a tree, the fourth or fifth rot column may be recorded in a set of columns that has been used previously, provided that at least one row for measurements that is blank in these columns separates the measurements of the two rot columns. Or, if any cross section of the tree bole has more than three cull areas, group the measurements in such a way as to result in recording measurements for three cull areas, one or two of which are actually composed of two separate cull areas.

All measurements recorded on the data sheet should be in feet and tenths and hundredths of feet. Faint vertical lines ruled in the columns would help to guide the placement of digits. To promote accuracy in keypunching, it is essential that digits be placed properly.

Although the heights at which the tree will be cut are already written into the columns headed Height Above Ground, every alternate row has been left blank so that an intermediate cut resulting in 4-foot sections could have measurements recorded. If cuts are taken at irregular heights, record them on the alternate rows and strike out the height figures that are printed on the other lines. At the top of the tree, record total tree height on an alternate line (unless by chance tree height is identical with one of the heights printed on the form), and record 000 under 1 and 2 for both DOB and DIB.

## Input Data for Felled Tree (Example 1)

A set of cards with felled-tree data (figs. 4 and 5) ready for a run is listed in figure 7. This example also shows two additional problems with the transition cards needed to terminate a problem and a run.

The format of the tree data in this example is as follows:

| | Column |
|---|---|
| Plot number | 1-3 |
| Tree number | 4-6 |
| Species | 10-12 |
| D.b.h. (1/10 inches) | 13-15 |
| Age | 16-18 |
| Height of section (1/10 feet) | 22-26 |
| D.o.b. | 27-29 |
| D.o.b. | 30-32 |
| D.i.b. | 33-35 |
| D.i.b. | 36-38 |
| DBT | 39-41 |
| 1st Dim. of 1st cull column | 42-44 |
| 2nd Dim. of 1st cull column | 45-47 |
| Shape of 1st cull column | 48 |
| As above for 2nd cull column | 50-56 |
| As above for 3rd cull column | 58-64 |
| F for fork indicator | 78 |

```
   1 1
0019 1 5 6 7 1 1 0 2 1 F   2 1 2 116.0000.40
   1  39  10                            30  10   2        0   0
(2I3,3X,I3,F3.1,I3,3X,F5.1,    5F3.2,   3(2F3.2,A1,1X),3A4,A1)
113
113801    073223197      1.0363363       045
113801    073223197      4.518018015812903018001OR
113801    073223197      9.116616614812501420001 5R
113801    073223197     17.314814813811600816003OR
113801    073223197     25.4139136129128    100010R
113801    073223197     33.6134133123129    030005R
113801    073223197     37.6131130121125
113801    073223197     41.7128127122118
113801    073223197     49.9126126116117
113801    073223197     58.0123123113113
113801    073223197     66.2110113103106
113801    073223197     74.3103106098099
113801    073223197     82.5095096086085
113801    073223197     90.6080081072076
113801    073223197     98.8066066058059
113801    073223197    106.9048051043045
113801    073223197    128.0000000000000
```

← *Blank card terminates plot 113.*

```
099
099306    202237220      1.0240292220265    070056E
099306    202237220      4.5200274243189    061035R
099306    202237220      9.1240176215163    052031R
099306    202237220     17.3210189191175    047027R 040038E
099306    202237220     25.4188173172166    031013R 060041E 032015E
099306    202237220     33.6183181169164            053036R 039022E
099306    202237220     41.7175174159159            042027R 043036R
099306    202237220     49.9162160146147            018022E 060043R
099306    202237220     58.0153153140141                    057042E
099306    202237220     66.2136140124130                    054040E
099306    202237220     74.3125122111112    036028E         052040E
099306    202237220     82.5104110098100    039030E         034023E
099306    202237220     90.6083082075074    030025R
099306    202237220     98.8063061059056    025014R
099306    202237220    106.9047047044044    014009E
099306    202237220    121.0000000000000
```

← *2 blank cards terminate plot and problem.*

```
  69 1 5 6 7 1 1 0 2 1 F   2 1 2 116.0000.40
   1  39  10                            30  10   2        0   0
(2I3,3X,I3,F3.1,I3,3X,F5.1,    5F3.2,   3(2F3.2,A1,1X),3A4,A1)
829
829401016202143062093001.0155147136129
829401016202143062093017.3098100094095
829401016202143062093033.6086086080079
829401016202143062093049.9065067061062
829401016202143062093062.1045045042041
829401016202143062093083.8000     000
```

```
   1 1 5 6 7 1 1 0 2 1 F 1 2 2 2 216.0000.40
   1  65  15  10  30   1  25  20  35  10   2   1   0   0   1
(2I3,3X,I3,F3.1,I3,3X,F5.1,    5F3.2,   3(2F3.2,A1,1X),3A4,A1)
 14  1
014102014108154108   001.0131159125153    109095E
014102014108154108   004.5135122130116    040030R
014102014108154108   009.1120114116109
014102014108154108   017.3105101100095
014102014108154108   025.4085088082085
014102014108154108   033.6084080081078
014102014108154108   041.7074067070064
014102014108154108   049.9060058058056
014102014108154108   058.0047046045044
014102014108154108   066.2031027029025
014102014108154108   078.0000000000000
```

← *3 blank cards terminate plot, problem, and run.*

```
/*                END OF DATA
```

Figure 7.--List of input data cards for felled trees ready for computing. The first two trees represent the data shown in figures 4 and 5.

## Instructions for Recording Dendrometry Data--Standing Trees (Example 2)

To ensure that tree measurements are punched into cards accurately for easy processing, special care must be taken in recording dendrometer measurements. Another important reason for being careful in recording data is that a measurement once lost cannot be retaken 6 months later when one is a thousand miles away.

The form we have used (fig. 8)[11] for recording dendrometer measurements in the field has several spaces marked at the top where information pertaining to the entire tree is recorded. These spaces are named and carry numbers corresponding to the data card columns in which the digits recorded therein will be punched. The bottom portion of the field form contains four columns (T, F, S, and G), which are used to record measurements taken on the bole. Each row, across all four columns, contains the measurements taken at a particular height on the tree. Thus, a single row of figures on

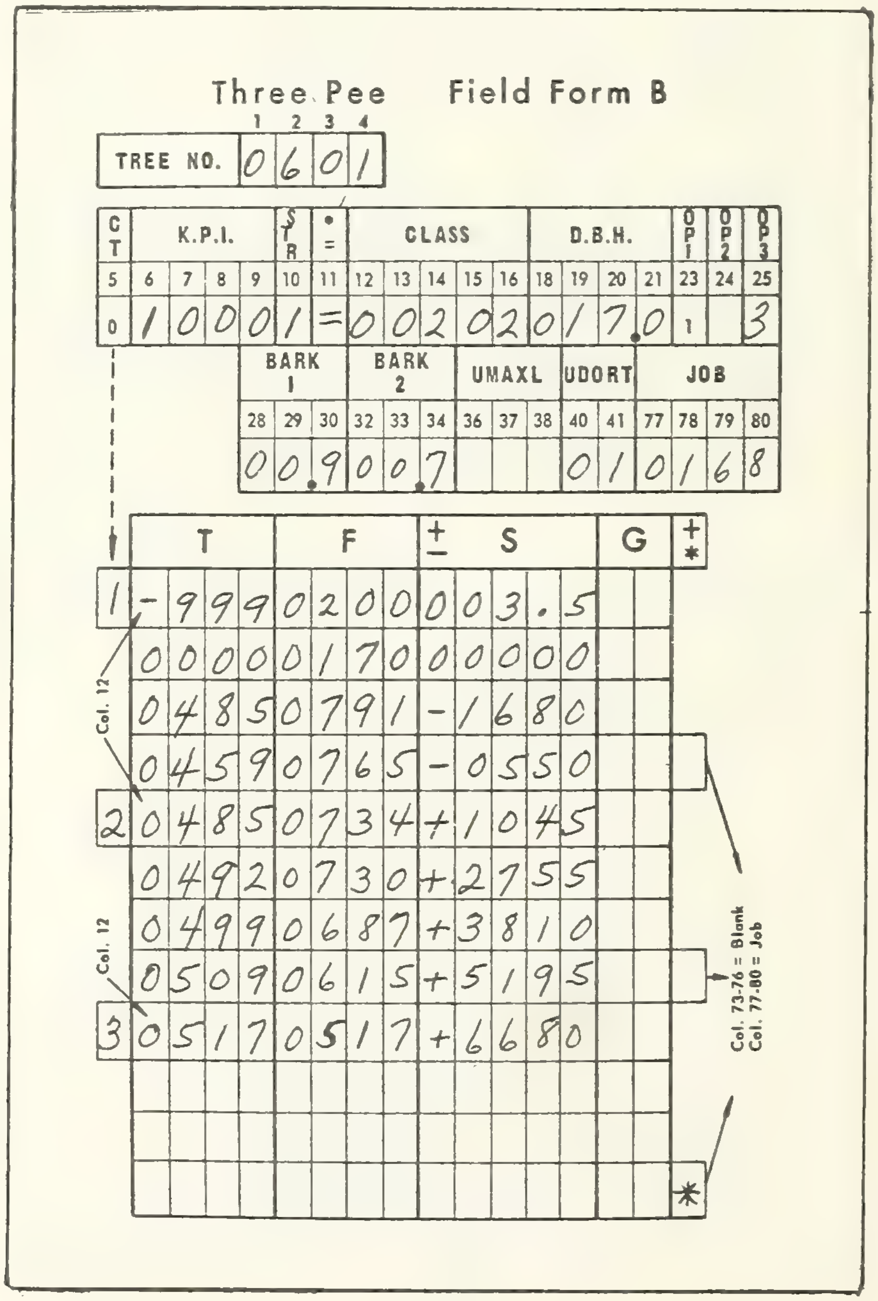



Figure 8. -- Dendrometer measurements for non-forked tree recorded on field form.

[11] Designed by F. A. Johnson, Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service.

the lower portion of the form in column T contains the TGRADS reading at that height on the tree. Column F contains the FGRADS reading, and column S contains the sine elevation reading. Four rows across the columns contain the data to be punched into one card. Note that the first, fifth, and ninth lines have space for an extra digit on the left edge of the TGRADS column. In these places put 1, 2, and 3 in consecutive order to denote the first, second, and third card on which the data will be punched. If the number of measurements taken on any tree necessitates continuation on another card, write 4, 5, 6, etc., in corresponding spaces on the second card. The fourth, eighth, and twelfth lines contain similar extra spaces at the right of the double column headed G. The characters written in these spaces denote the last measurement for a particular tree on a given punch card, and signify the kind of measurements for the same tree that will follow on the next punch card. This will be discussed in detail later.

Consider once more the data spaces on the top half of the field form. What follows describes the entry of data into them.

| Item | Column |
|---|---|
| TREE NO. | 1-4 |
| CT (Card counter) | 5 |
| KPI (Value prediction in 3P sampling | 6-9 |
| STR (Stratum) | 10 |
| CERT (*, =) (Distinguishes probability-sample trees from sure-to-be-measured trees in 3P sampling) | 11 |
| CLASS (Species) | 12-16 |
| D.b.h. (Inches and tenths. Decimal is implied between columns 20 and 21) | 18-21 |
| OP1 . . . OP3 (Not used by NETVSL) | 23-25 |
| BARK1 (Enter two bark thickness measurements taken at breast height | 28-30 |
| BARK2 Implied decimals between columns 29-30 and 33-34, respectively) | 32-34 |
| UMAXL (Not used by NETVSL) | 36-38 |
| UDORT (Not used by NETVSL) | 40-41 |
| JOB (Use only 3-digit plot number number for NETVSL. Enter zero in column 77) | 77-80 |

The top portion of the field form (fig. 8) can be completed in far less time than it takes to tell about it. Dendrometer measurements are recorded on the lower portion in the columns headed T, F, and ±S. The column headed G may be used to record the grade of the section below the point of observation. The following section on measurements describes the proper recording of data line by line and column by column, following the sequence in which measurements will be taken.

## First Measurement

The first measurement to be recorded is stump diameter. The one-digit box added at the left edge of the first line of column T contains 1. This shows, when the data are punched into cards, that the card containing the first four rows of dendrometer measurements is first in the sequence of dendrometer cards for this particular tree.

In the T column, enter -999. This is not a real TGRADS reading, but it signifies that this is the first measurement on the tree and that it is a taped measurement rather than a set of dendrometer readings. In the F column, 0200 is recorded--the stump diameter (o.b.) of the tree, 20.0 inches. The decimal point is understood to be between the third and fourth digit of 0200. It is not written on the field form, but the computer program assumes it to be there when the data are processed. The leading 0 is written in to fill the space. In the ±S column, 003.5 is entered. Although this is the sine elevation column, the number entered here on the first row is not a sine elevation because the first measurement is not a dendrometer measurement. Rather, this entry is the distance in feet up the tree to the next measurement. On this tree it was 3.5 feet from stump height to breast height, where the next measurement was taken. The decimal point in this entry is written by the notekeeper. Leading 0's are also entered as shown in figure 8.

### Second Measurement

The next measurement on the tree, which is d.b.h. measured with a tape, is recorded on the second row. For this level, four 0's are entered in the T column. Diameter at breast height, in inches and tenths, is entered on the second row in column F in the same way that stump diameter was entered on the first row. For this tree, d.b.h. was 17.0 inches. In the upper part of this form, 0170 is entered in the d.b.h. space. In the second row of the ±S column, five consecutive 0's are entered for this measurement. This shows that the next measurement on the tree, which follows on the third row, will be taken at the same height as the second measurement.

### Third Measurement

The third measurement is d.b.h. again, but measured this time with the dendrometer. Now, on the third row the T column contains, at long last, a true TGRADS reading, namely, 0485, entered as shown. Column F contains a true FGRADS reading, 0791, entered as shown. The ±S column contains the first sine elevation reading, namely, -1680.

### Subsequent Measurements

Dendrometer readings for the first level of measurement above breast height are recorded on the fourth row. In this example, sine elevation readings are increasing and continue to increase to the top of the tree. Notice also that all sine elevation readings end in either 0 or 5. This is because it is possible to estimate the instrument reading to this degree of precision, but no closer. Even so, this is more precision than the instrument was intended to give. However, if the instrument location is changed,[12] the continuous increase in sine elevation may be disrupted. As figure 8 demonstrates, the FGRADS readings usually decrease as tree height increases. Occasionally, FGRADS may increase slightly, but usually they decrease. After each set of instrument readings is taken, the trend of FGRADS should be checked; if an increase is noted, measurements should be checked before the instrument is moved. A short section of a tree trunk may show negative taper, but this is fairly uncommon. The third level of measurements above breast height is recorded on row 5 of this field form. A 2 is recorded in the box at the left of the T column to show that this row records the first set of readings that will be punched into the second data card for this tree.

Measurements are taken at irregular intervals up the stem separating portions of uniform taper and grade. Readings taken at the top of the tree are recorded on line 9 of the field form. The TGRAD and FGRAD readings at the top of the tree are identical, indicating a zero diameter. The last box on the right of the G column at the bottom of the field form contains an asterisk (*), which shows that the third punched card will be the last card containing data for this tree.

---

[12] One move to a different instrument location up or down hill is permitted.

## Continuation on a Second Sheet

If enough measurements are made on a single tree to require continuation on a second sheet, fill the spaces at the top of the second sheet so as to duplicate the first card. Write "continued" at the top of the second sheet (and the third, if necessary). On the first sheet write "1 of 2" or "1 of 3" in the upper right-hand corner. On the second (or third) write "2 of 2" or "3 of 3," etc., in the upper right-hand corner (fig. 9).

## Forked Trees

Figure 9 shows how data for forked trees are recorded. After the stump and d.b.h. measurements are recorded, instrument readings are recorded up to the last measurement below the fork, corresponding to measurement 4. The readings taken at such a point were recorded on the fourth row of the first sheet. The sine elevation reading at this level is -1000, and a plus sign (+) is recorded in the extra box on the right edge of column G. This keys the computer program to compute the volume of the next section of tree trunk separately and to add it to the volume that has already been accumulated.

Measurements for the first fork follow, starting on the fifth row. Note that the sine elevation recorded for the bottom of the fork is about the same as that recorded for the top of the first trunk section. Measurements are then taken up the stem of the fork and recorded as shown. At the top of the first fork, TGRADS and FGRADS readings are equal (line 11 of card 1). No dendrometer readings are recorded on the twelfth line.

The measurements for the second fork are punched into a different set of data cards. In the deck of punched cards for a tree, it is essential that measurements for the portion of the trunk below a fork and for the forked portions not be punched into the same card. For this reason the twelfth line on the first card is left blank except for the slash (/) in the extra box at the right of column G. On the first line of the lower portion of the sheet for this tree (which will be the first set of measurements on the fourth punched card), are entered the dendrometer readings for the bottom of the second fork. Dendrometer readings are then recorded for successive levels of measurement up the stem of the fork until the top is reached. The first box at the right of column G following the last entry of data (which happens to be on the same line on this card) then contains an asterisk (*) to signify the end of data for that tree.

## Change in Instrument Location

The dendrometer may be moved from one observation level to another without special recording procedures *only if* the new location is on the same horizontal plane as the previous location.

One move to a different horizontal plane is permitted. The way in which data are recorded after change to a new elevation is shown in figure 10. Measurements are taken and recorded in the usual fashion until it is desirable to move the instrument to a new location. Readings taken at this new level are recorded on line 6 of the sample form (fig. 10).

Data for forked trees require special precaution when the instrument is moved because the plus character is used to indicate both (1) the point at which a fork leaves the bole and (2) the relocation of the instrument. To overcome this ambiguity, the convention has been adopted that only the first plus recorded for a forked tree can represent a relocation. All subsequent plus characters are interpreted as fork locations. A + sign is then placed as shown on line 8. After the instrument is set up at the new location, a measurement is taken at the same height on the tree as the last

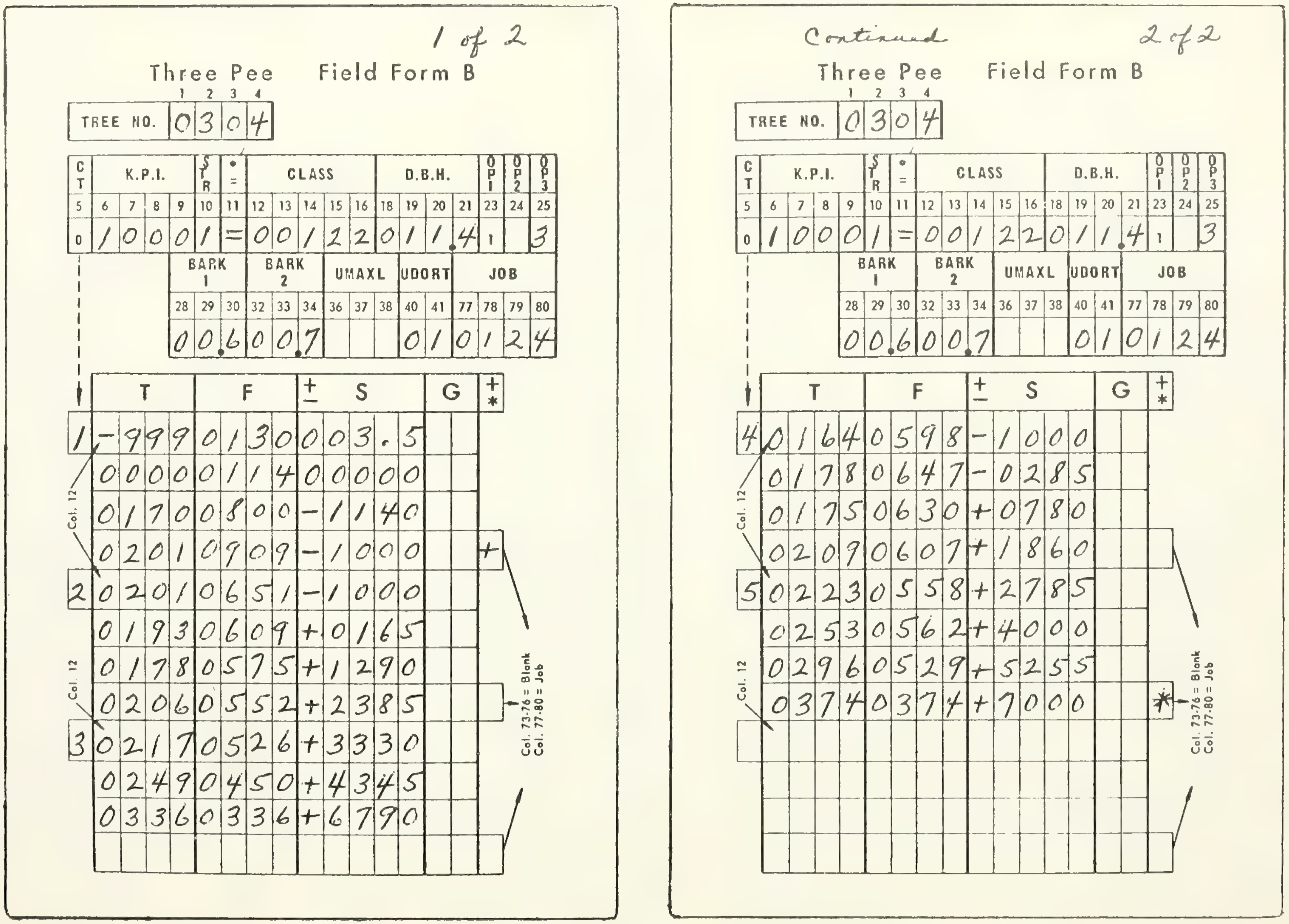
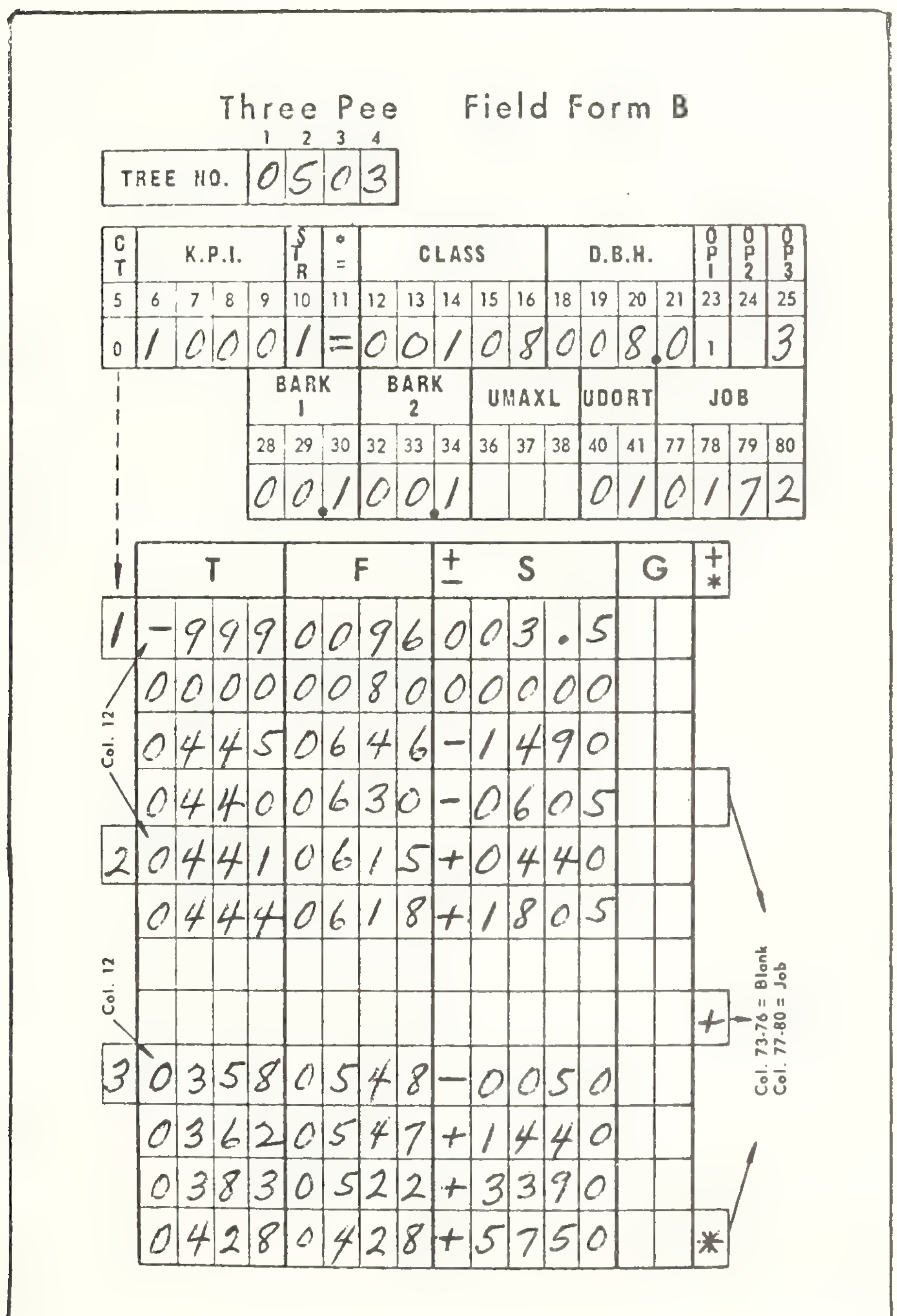



Figure 9.--Record of dendrometer data for a forked tree.

measurement taken at the previous location. Therefore, the data recorded on line 9 (fig. 10) were taken at the same height as those recorded on line 6, but from the new location. Measurements are then taken and recorded up to the top of the tree in the normal manner.



Three Pee Field Form B

| TREE NO. (1 2 3 4) |
| --- |
| 0 5 0 3 |

| CT (5) | K.P.I. (6–9) | STR (10) | ° = (11) | CLASS (12–16) | D.B.H. (18–21) | OP1 (23) | OP2 (24) | OP3 (25) |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1000 | 1 | = | 00108 | 008.0 | 1 | | 3 |

| BARK 1 (28–30) | BARK 2 (32–34) | UMAXL (36–38) | UDORT (40–41) | JOB (77–80) |
| --- | --- | --- | --- | --- |
| 00.1 | 00.1 | | 01 | 0172 |

| | T | F | ± S | G | + * |
| --- | --- | --- | --- | --- | --- |
| 1 | -999 | 0096 | 003.5 | | |
| | 0000 | 0080 | 00000 | | |
| | 0445 | 0646 | -1490 | | |
| | 0440 | 0630 | -0605 | | |
| 2 | 0441 | 0615 | +0440 | | |
| | 0444 | 0618 | +1805 | | |
| | | | | | |
| | | | | | + |
| 3 | 0358 | 0548 | -0050 | | |
| | 0362 | 0547 | +1440 | | |
| | 0383 | 0522 | +3390 | | |
| | 0428 | 0428 | +5750 | | * |

Col. 12

Col. 12

Col. 73-76 = Blank
Col. 77-80 = Job

Figure 10.--Recording dendrometer data when instrument location is changed.

## APPENDIX B

### ERROR MESSAGES AND DIAGNOSTICS

The main program in NETVSL calls many subprograms to accomplish particular phases of the calculations. After the calls to most of the subprograms, the main program tests the status of the variable: IERROR. If IERROR is nonzero, this error message is printed in which xxxxx, yyyyy, and zzzzz are replaced by the values of IERROR, JERROR, and KERROR, respectively:

ERROR xxxxx HAS OCCURRED IN SECTION yyyyy. ERROR COUNT = zzzzz.

The value of KERROR is incremented by one *each* time an error condition is encountered, and the tree is omitted from further processing.

The values of IERROR and their associated diagnostics are grouped by the subprograms in which they arise in the following list.

| Subprogram | IERROR | Interpretation |
|---|---|---|
| DIALEN | 401 | Number of sections is greater than the 40 storage locations provided. If this is true, the program dimensions must be increased. Otherwise, look for such situations as duplicated tree numbers in successive trees, or missing asterisks on dendrometer cards. |
| | 402 | Number of forks is greater than the eight storage locations provided. If this is true, the program dimensions must be increased, or the tree pruned. |
| | 403 | Number of forks as indicated by the occurrence of fork codes does not match the number of tops indicated by zero diameters. Check for missing fork codes or extraneous zero diameters. |
| | 404 | Negative diameter found. Check data for cause. |

Each of the above errors will cause DEBUG output to be printed.

| | | |
|---|---|---|
| BOARDF | 801 | See DIALEN 401 above. |
| | 802 | Indexes are in error in calculating the positions of saw-log tops. If there are no previous errors for this tree, obtain DEBUG output and consult with the senior author. |
| CUAREA | 1101 | An error has occurred in matching the cull codes of the data with the cull code keys stored in BLOCK DATA. This matching is accomplished in CULVOL. Check that NCODE has not been initialized to a value greater than 10 in BLOCK DATA. |

| | | |
|---|---|---|
| READIN | 1201 | The plot number on the section being processed does not agree with the plot number on the preceding PLOT OPTION CARD. Check data sequencing. |
| | 1202 | See DIALEN 401 above. |
| | 1204 | A card sequence error has been detected among the dendrometer cards. Check data sequence. |
| FORMF | 1301 | Form factor of nonforked tree is suspiciously large. |

In addition to the above errors, which will cause the offending tree to be skipped, one message that may be printed in DIALEN may indicate erroneous data. DIALEN checks that the length of each section is greater than 0.0001 foot. If not, the message:

LENGTH OF SECTION FLN(I) = y CHANGED TO 0.0001

is printed with the index of the section and its prior length inserted in place of I and y, respectively. With dendrometry data, small negative lengths may result from small errors of measurement of closely spaced sections. In this case, if FLN(I) is reasonably close to zero, the volume calculations should not be seriously affected. Otherwise, the data sequencing and recording should be checked for errors.

AFPS, Ogden, Utah

Stage, Albert R., Richard C. Dodge, and James E. Brickell.
1968. NETVSL--a computer program for calculation of tree volumes with interior defect. Intermountain Forest and Range Exp. Sta., Ogden, Utah, 84401. 30 pp., illus. (U.S. Forest Serv. Res. Pap. INT-51)

This comprehensive computer program, written in FORTRAN IV language, calculates gross and net volume, surface area, and length from stem measurements. Tree input data include measurements of lengths, diameters, and cull dimensions obtained from felled trees; gross volumes of standing trees may be computed from Barr and Stroud optical dendrometer measurements. Volume units include cubic feet, Scribner and International 1/4" log scale. Various merchantability standards can be applied simultaneously to identical input data to obtain correspondingly various volume data output. This paper includes typical instructions for collecting and compiling tree data.

Stage, Albert R., Richard C. Dodge, and James E. Brickell.
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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Project headquarters are also at:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
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